

The Genetic Code

The main function of genes is to control the production of proteins in an organism's cells. Proteins help to determine the size, shape, color, and many other traits of an organism.

Genes and DNA Recall that chromosomes are composed mostly of DNA. In Figure 16, you can see the relationship between chromosomes and DNA. Notice that a DNA molecule is made up of four different nitrogen bases—adenine (A), thymine (T), guanine (G), and cytosine (C). These bases form the rungs of the DNA “ladder.”

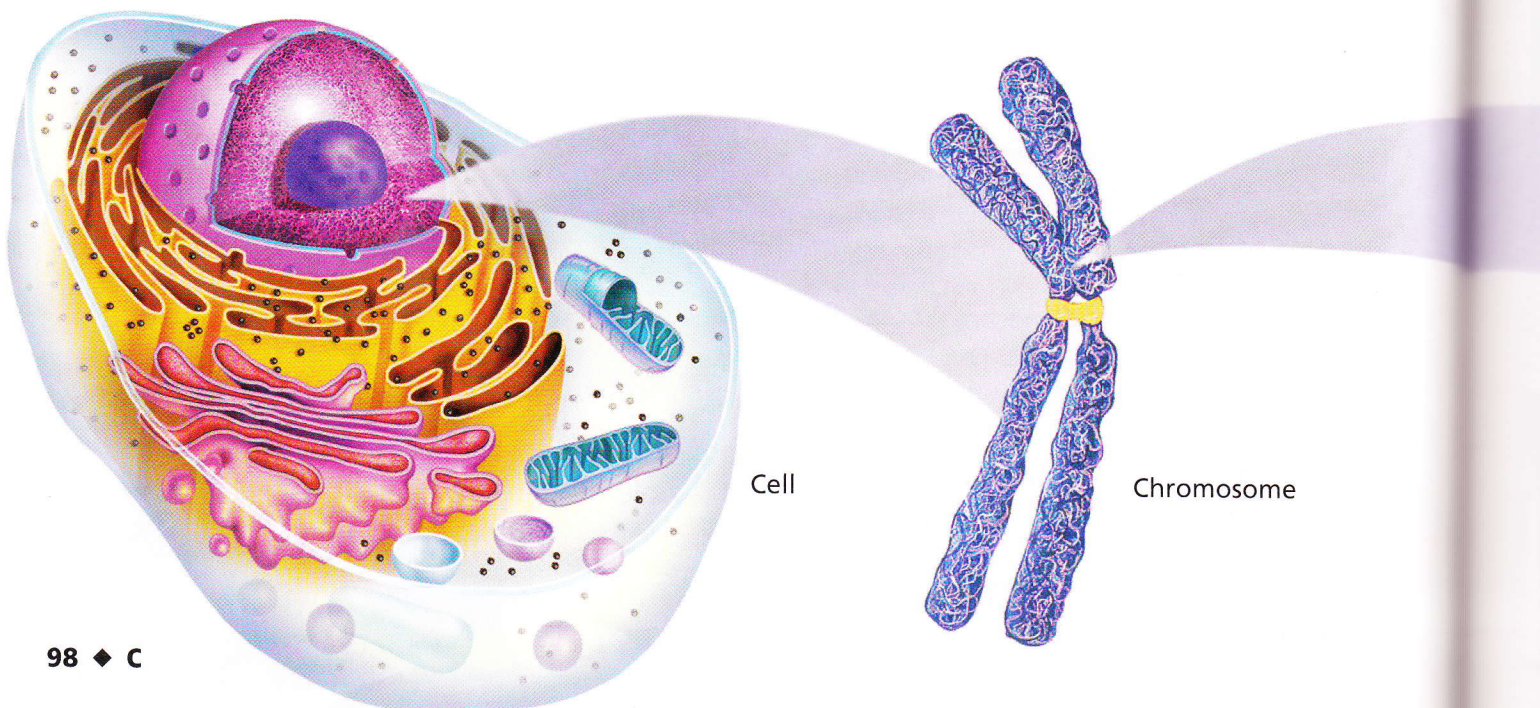
A gene is a section of a DNA molecule that contains the information to code for one specific protein. A gene is made up of a series of bases in a row. The bases in a gene are arranged in a specific order—for example, ATGACGTAC. A single gene on a chromosome may contain anywhere from several hundred to a million or more of these bases. Each gene is located at a specific place on a chromosome.

Order of the Bases A gene contains the code that determines the structure of a protein. **The order of the nitrogen bases along a gene forms a genetic code that specifies what type of protein will be produced.** Remember that proteins are long-chain molecules made of individual amino acids. In the genetic code, a group of three DNA bases codes for one specific amino acid. For example, the base sequence CGT (cytosine-guanine-thymine) always codes for the amino acid alanine. The order of the three-base code units determines the order in which amino acids are put together to form a protein.

FIGURE 16

The DNA Code

Chromosomes are made of DNA. Each chromosome contains thousands of genes. The sequence of bases in a gene forms a code that tells the cell what protein to produce. **Interpreting Diagrams** *Where in the cell are chromosomes located?*



How Cells Make Proteins

The production of proteins is called protein synthesis. During **protein synthesis**, the cell uses information from a gene on a **chromosome to produce a specific protein**. Protein synthesis takes place on the ribosomes in the cytoplasm of a cell. As you know, the cytoplasm is outside the nucleus. The chromosomes, however, are found inside the nucleus. How, then, does the information needed to produce proteins get out of the nucleus and into the cytoplasm?

The Role of RNA Before protein synthesis can take place, a “messenger” must first carry the genetic code from the DNA inside the nucleus into the cytoplasm. This genetic messenger is called ribonucleic acid, or RNA.

Although RNA is similar to DNA, the two molecules differ in some important ways. Unlike DNA, which has two strands, RNA has only one strand. RNA also contains a different sugar molecule from the sugar found in DNA. Another difference between DNA and RNA is in their nitrogen bases. Like DNA, RNA contains adenine, guanine, and cytosine. However, instead of thymine, RNA contains uracil (YOOR uh sil).

Types of RNA There are several types of RNA involved in protein synthesis. **Messenger RNA** copies the coded message from the DNA in the nucleus, and carries the message to the ribosome in the cytoplasm. Another type of RNA, called **transfer RNA**, carries amino acids to the ribosome and adds them to the growing protein.

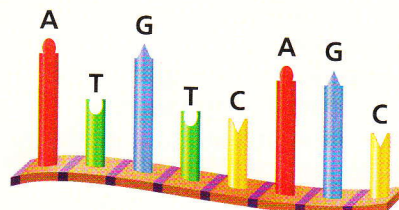


How is RNA different from DNA?

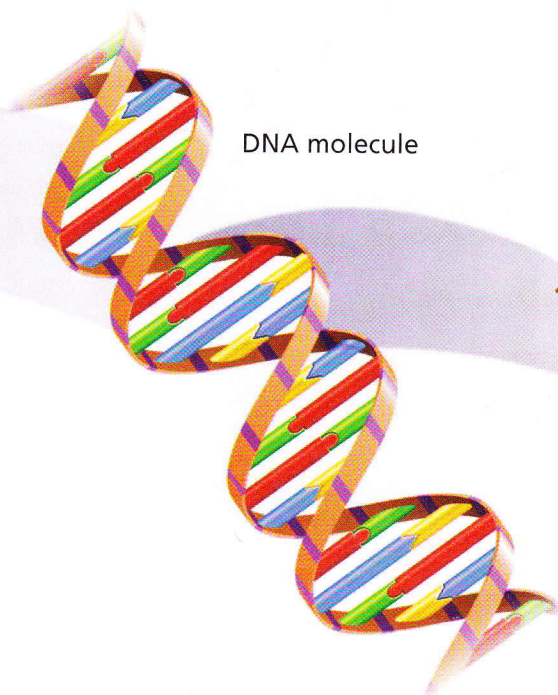
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Drawing Conclusions

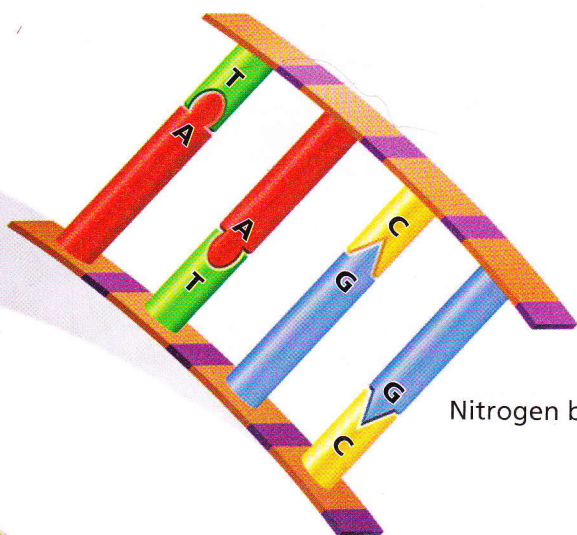
The following is a sequence of nitrogen bases on one strand of a nucleic acid molecule.



Does the strand come from DNA or RNA? Explain your answer.



DNA molecule



Nitrogen bases

FIGURE 17

Protein Synthesis

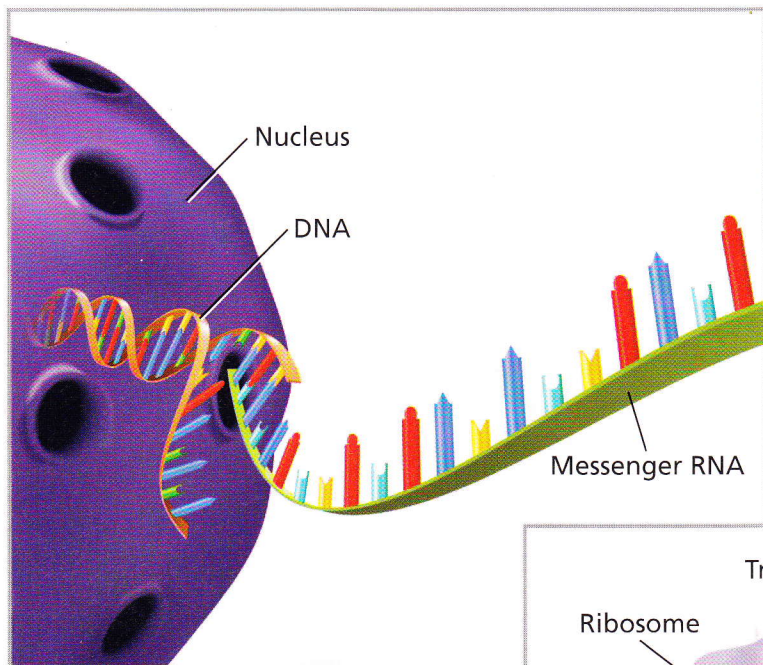
To make proteins, messenger RNA copies information from DNA in the nucleus. Messenger RNA and transfer RNA then use this information to produce proteins.

Interpreting Diagrams In which organelle of the cell are proteins manufactured?

Translating the Code The process of protein synthesis is shown in Figure 17. Look at the illustration as you read the following steps.

❶ The first step is for a DNA molecule to “unzip” between its base pairs. Then one of the strands of DNA directs the production of a strand of messenger RNA. To form the RNA strand, RNA bases pair up with the DNA bases. The process is similar to the process in which DNA replicates. Cytosine always pairs with guanine. However, uracil—not thymine—pairs with adenine.

❷ The messenger RNA then leaves the nucleus and enters the cytoplasm. In the cytoplasm, messenger RNA attaches to a ribosome. On the ribosome, the messenger RNA provides the code for the protein molecule that will form. During protein synthesis, the ribosome moves along the messenger RNA strand.

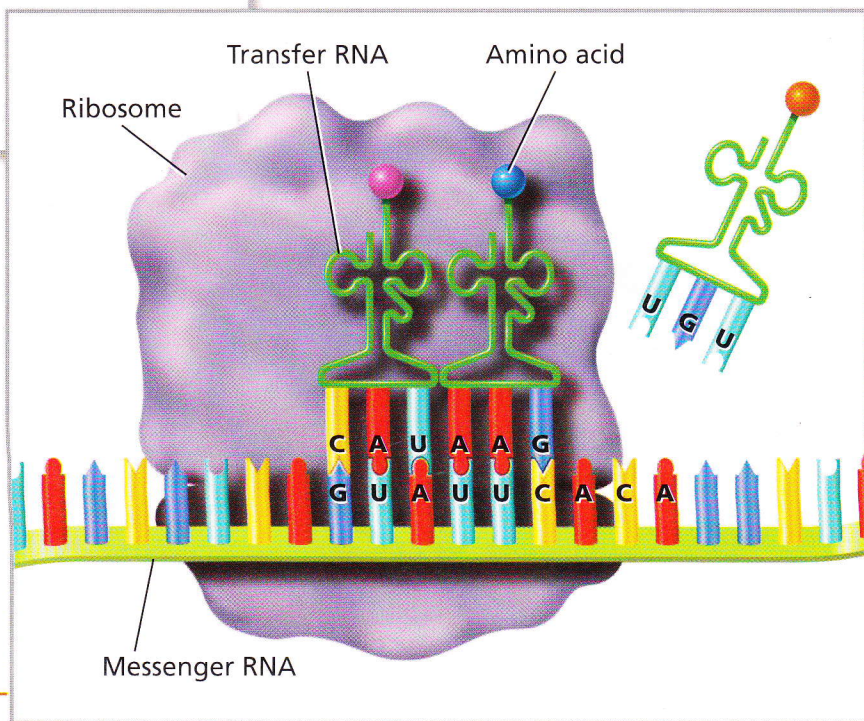


❶ Messenger RNA Production ▲

In the nucleus, a DNA molecule serves as a “pattern” for making messenger RNA. The DNA molecule “unzips” between base pairs. RNA bases match up along one of the DNA strands. The genetic information in the DNA is transferred to the messenger RNA strand.

❷ Messenger RNA Attaches to a Ribosome ▼

When the messenger RNA enters the cytoplasm, it attaches to a ribosome, where production of the protein chain begins. The ribosome moves along the messenger RNA strand.



3 Molecules of transfer RNA attach to the messenger RNA. The bases on the transfer RNA “read” the message by pairing up three-letter codes to bases on the messenger RNA. For example, you can see that a molecule of transfer RNA with the bases AAG pairs with the bases UUC on the messenger RNA. The molecules of transfer RNA carry specific amino acids. The amino acids link in a chain. The order of the amino acids in the chain is determined by the order of the three-letter codes on the messenger RNA.

4 The protein molecule grows longer as each transfer RNA molecule puts the amino acid it is carrying along the growing protein chain. Once an amino acid is added to the protein chain, the transfer RNA is released into the cytoplasm and can pick up another amino acid. Each transfer RNA molecule always picks up the same kind of amino acid.



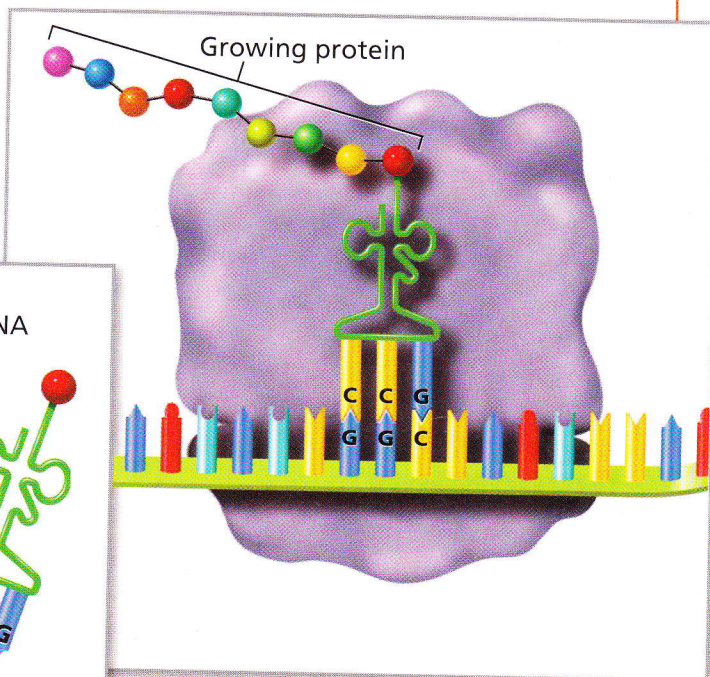
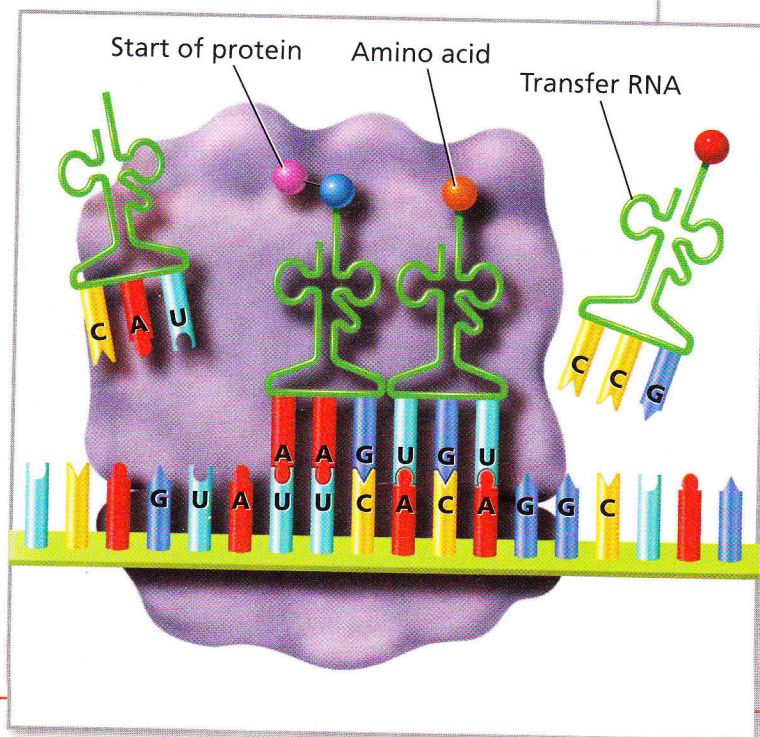
What is the function of transfer RNA?

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3 Transfer RNA Attaches to Messenger RNA ▼

Transfer RNA molecules carry specific amino acids to the ribosome. There they “read” the message in messenger RNA by matching up with three-letter codes of bases. The protein chain grows as each amino acid is attached.



4 Protein Production Continues ▲

The protein chain continues to grow until the ribosome reaches a three-letter code that acts as a stop sign. The ribosome then releases the completed protein.